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Network science: a useful tool in economics and finance

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Abstract

The increasing frequency and scope of financial crises has made global financial stability one of the major concerns of economic policy and decision makers. Under this highly complex environment, supervision of the financial system has to be thought of as a systemic task, focusing not only on the strength of the institutions but also on the interdependent relations among them, unraveling the structure and dynamic of the system as a whole. In recent years, network science has emerged as a leading tool for the investigation of complex systems. Here we review several applications of network science in finance and economics, and discuss existing challenges and future directions which will substantiate network science as a key tool for financial academics, practitioners, and policy and decision makers.

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References

Acemoglu D, Malekian A, Ozdaglar A (2013a) Network security and contagion. Technical report, National Bureau of Economic Research

Acemoglu D, Ozdaglar A, Tahbaz-Salehi A (2013b) The network origins of large economic downturns. Technical report, National Bureau of Economic Research

Acemoglu D, Ozdaglar A, Tahbaz-Salehi A (2013c) Systemic risk and stability in financial networks. Technical report, National Bureau of Economic Research

Aguiar A, Bookstaber R, Wipf T (2014) A map of funding durability and risk. Off Financ Res Work Pap Ser 14(03)

Albert R, Barabási A-L (2002) Statistical mechanics of complex networks. Rev Mod Phys 74(1):47

Allen F, Gale D (1998) Optimal financial crises. J Financ 53(4):1245–1284

Amini H, Cont R, Minca A (2012) Stress testing the resilience of financial networks. Int J Theor Appl Financ 15(01)

Amman HM, Tesfatsion L, Judd KL, Kendrick DA, Rust J (2006) Handbook of computational economics, vol 2. Elsevier, Amsterdam

Arenas A, Díaz-Guilera A, Kurths J, Moreno Y, Zhou C (2008) Synchronization in complex networks. Phys Rep 469(3):93–153

Barabási A-L, Albert R (1999) Emergence of scaling in random networks. Science 286(5439):509–512

Barabási A-L, Frangos J (2014) Linked: the new science of networks. Basic Books, New York

Bargigli L, Di Iasio G, Infante L, Lillo F, Pierobon F (2015) The multiplex structure of interbank networks. Quant Financ 15(4):673–691

Barrat A, Barthelemy M, Pastor-Satorras R, Vespignani A (2004) The architecture of complex weighted networks. Proc Natl Acad Sci USA 101(11):3747–3752

Bashan A, Bartsch RP, Kantelhardt JW, Havlin S, Ivanov PC (2012) Network physiology reveals relations between network topology and physiological function. Nat Commun 3:702

Battiston S, Puliga M, Kaushik R, Tasca P, Caldarelli G (2012) Debtrank: too central to fail? Financial networks, the fed and systemic risk. Sci Rep 2

Billio M, Getmansky M, Lo AW, Pelizzon L (2012) Econometric measures of connectedness and systemic risk in the finance and insurance sectors. J Financ Econ 104(3):535–559

Boccaletti S, Latora V, Moreno Y, Chavez M, Hwang D-U (2006) Complex networks: structure and dynamics. Phys Rep 424(4):175–308

Boccaletti S, Bianconi G, Criado R, Del Genio C, Gómez-Gardeñes J, Romance M, Sendiña-Nadal I, Wang Z, Zanin M (2014) The structure and dynamics of multilayer networks. Phys Rep 544(1):1–122

Bonanno G, Caldarelli G, Lillo F, Mantegna RN (2003) Topology of correlation-based minimal spanning trees in real and model markets. Phys Rev E 68(4):046130

Bookstaber RM, Kenett DY (2015) The multilayer structure of the financial system (preprint)

Bookstaber R, Paddrik M, Tivnan B (2014) An agent based model for financial vunerability. Off Financ Res Work Pap Ser 14(05)

Bookstaber R, Glasserman P, Iyengar G, Luo Y, Venkatasubramanian V, Zhang Z (2015) Process systems engineering as a modeling paradigm for analyzing systemic risk in financial networks. Off Financ Res Work Pap Ser 15(01)

Borgatti SP, Everett MG (2000) Models of core/periphery structures. Soc Netw 21(4):375–395

Boss M, Elsinger H, Summer M, Thurner S IV (2004) Network topology of the interbank market. Quant Financ 4(6):677–684

Buldyrev SV, Parshani R, Paul G, Stanley HE, Havlin S (2010) Catastrophic cascade of failures in interdependent networks. Nature 464(7291):1025–1028

Caldarelli G (2007) Scale-free networks: complex webs in nature and technology. Oxford University Press, Oxford

Cantono S, Solomon S (2010) When the collective acts on its components: economic crisis autocatalytic percolation. N J Phys 12(7):075038

Cepeda F (2008) La topología de redes como herramienta de seguimiento en el sistema de pagos de alto valor en colombia. Borradores de Economía 513

Cohen R, Erez K, Ben-Avraham D, Havlin S (2000) Resilience of the internet to random breakdowns. Phys Rev Lett 85(21):4626

Cohen R, Havlin S, Ben-Avraham D (2003) Efficient immunization strategies for computer networks and populations. Phys Rev Lett 91(24):247901

Cohen R, Havlin S (2010) Complex networks: structure, robustness and function. Cambridge University Press, Cambridge

Cont R (2013) Networks: introduction. In: Fouque JP, Langsam JA (eds) Handbook on systemic risk, vol 285. Cambridge University Press, Cambridge

Cont R, Moussa A, Santos EB et al (2013) Network structure and systemic risk in banking systems. In: Handbook of systemic risk. Cambridge University Press, Cambridge, pp 327–368

Craig B, Von Peter G (2014) Interbank tiering and money center banks. J Financ Intermed 23(3):322–347

Curme C, Tumminello M, Mantegna RN, Stanley HE, Kenett DY (2015) Emergence of statistically validated financial intraday lead–lag relationships. Quant Financ. doi:10.1080/14697688.2015.1032545

Drehmann M, Tarashev N (2013) Measuring the systemic importance of interconnected banks. J Financ Intermed 22(4):586–607

Elsinger H, Lehar A, Summer M (2005) Using market information for banking system risk assessment. Available at SSRN: 787929

Elsinger H, Lehar A, Summer M (2006) Risk assessment for banking systems. Manag Sci 52(9):1301–1314

Erdős P, Rényi A (1959) On random graphs. Publicat Math Debr 6:290–297

Faloutsos M, Faloutsos P, Faloutsos C (1999) On power–law relationships of the internet topology. In: ACM SIGCOMM computer communication review, vol 29. ACM, New York, pp 251–262

Fricke D, Lux T (2015) Core-periphery structure in the overnight money market: evidence from the e-mid trading platform. Comput Econ 45:359–395

Furfine CH (2003) Interbank exposures: quantifying the risk of contagion. J Money Credit Bank 35(1):111–128

Galbiati M, Soramäki K (2012) Clearing networks. J Econ Behav Organ 83(3):609–626

Gao J, Buldyrev SV, Stanley HE, Havlin S (2012) Networks formed from

interdependent networks. Nat Phys 8(1):40–48

Garas A, Argyrakis P, Havlin S (2008) The structural role of weak and strong links in a financial market network. Eur Phys J B Condens Matter Complex Syst 63(2):265–271

Garas A, Argyrakis P, Rozenblat C, Tomassini M, Havlin S (2010) Worldwide spreading of economic crisis. N J Phys 12(11):113043

Glasserman P, Young HP (2015) How likely is contagion in financial networks? J Bank Financ 50:383–399

Haldane AG et al (2009) Rethinking the financial network. Financial Student Association, Amsterdam

Haldane AG, May RM (2011) Systemic risk in banking ecosystems. Nature 469(7330):351–355

Havlin S, Kenett DY, Ben-Jacob E, Bunde A, Cohen R, Hermann H, Kantelhardt J, Kertész J, Kirkpatrick S, Kurths J et al (2012) Challenges in network science: applications to infrastructures, climate, social systems and economics. Eur Phys J Spec Top 214(1):273

Helbing D (2013) Globally networked risks and how to respond. Nature 497(7447):51–59

Huang X, Vodenska I, Havlin S, Stanley HE (2013) Cascading failures in bi-partite graphs: model for systemic risk propagation. Sci Rep 3

Hüser A-C (2015) Too interconnected to fail: a survey of the interbank networks

literature. SAFE working paper no. 91 (available at SSRN 2577241)

Inaoka H, Ninomiya T, Taniguchi K, Shimizu T, Takayasu H (2004) Fractal network derived from banking transaction-an analysis of network structures formed by financial institutions. Bank Jpn Work Pap 4

Iñiguez G, Kertész J, Kaski KK, Barrio R (2009) Opinion and community formation in coevolving networks. Phys Rev E 80(6):066119

Iori G, De Masi G, Precup OV, Gabbi G, Caldarelli G (2008) A network analysis of the italian overnight money market. J Econ Dyn Control 32(1):259–278

Jackson MO (2010) Social economic networks. Princeton University Press, Princeton

Kenett DY, Tumminello M, Madi A, Gur-Gershgoren G, Mantegna RN, Ben-Jacob E (2010) Dominating clasp of the financial sector revealed by partial correlation analysis of the stock market. PloS One 5(12):15032

Kenett DY, Shapira Y, Madi A, Bransburg-Zabary S, Gur-Gershgoren G, Ben-Jacob E (2011) Index cohesive force analysis reveals that the us market became prone to systemic collapses since 2002. PloS One 6(4):19378

Kenett DY, Preis T, Gur-Gershgoren G, Ben-Jacob E (2012a) Dependency network and node influence: application to the study of financial markets. Int J Bifurc Chaos 22(7):1250181

Kenett DY, Raddant M, Zatlavi L, Lux T, Ben-Jacob E (2012b) Correlations in the global financial village. Int J Mod Phys Conf Ser 16(1):13–28

Kenett DY, Raddant M, Lux T, Ben-Jacob E (2012c) Evolvement of uniformity and volatility in the stressed global financial village. PloS One 7(2):31144

Kenett DY, Gao J, Huang X, Shao S, Vodenska I, Buldyrev SV, Paul G, Stanley HE, Havlin S (2014) Network of interdependent networks: overview of theory and applications. In: D'Agostino G, Scala A (eds) Networks of networks: the last frontier of complexity. Springer, Berlin, pp 3–36

Langfield S, Liu Z, Ota T (2012) Mapping the UK interbank system (manuscript). UK Financial Sevices Authority

LeBaron B (2006) Agent-based computational finance. Handb Comput Econ 2:1187–1233

Levy Carciente S, Kenett DY, Avakian A, Stanley HE, Havlin S (2014) Dynamical macro-prudential stress testing using network theory (available at SSRN 2482742)

Li D, Fu B, Wang Y, Lu G, Berezin Y, Stanley HE, Havlin S (2015) Percolation transition in dynamical traffic network with evolving critical bottlenecks. Proc Natl Acad Sci 112(3):669–672

Li W, Kenett DY, Yamasaki K, Stanley HE, Havlin S (2014) Ranking the economic importance of countries and industries (preprint). arXiv:1408.0443

Liljeros F, Edling CR, Amaral LAN, Stanley HE, Åberg Y (2001) The web of human sexual contacts. Nature 411(6840):907–908

Lillo F (2010) Networks in finance. In: Encyclopedia of life support systems (EOLSS), developed under the auspices of the UNESCO. Eolss Publishers, Oxford, UK

Lillo F, Moro E, Vaglica G, Mantegna RN (2008) Specialization and herding behavior of trading firms in a financial market. N J Phys 10(4):043019

Ludescher J, Gozolchiani A, Bogachev MI, Bunde A, Havlin S, Schellnhuber HJ (2014) Very early warning of next el niño. Proc Natl Acad Sci 111(6):2064–2066

Majdandzic A, Podobnik B, Buldyrev SV, Kenett DY, Havlin S, Stanley HE (2014) Spontaneous recovery in dynamical networks. Nat Phys 10(1):34–38

Mantegna RN (1999) Hierarchical structure in financial markets. Eur Phys J B Condens Matter Complex Syst 11(1):193–197

Martínez Jaramillo S, Kabadjova B, Bravo Benítez B, Solórzano Margain J (2012) Systemic risk analysis by means of network theory: an empirical study of the Mexican banking system. Technical report, Banco de México working papers

Milo R, Shen-Orr S, Itzkovitz S, Kashtan N, Chklovskii D, Alon U (2002) Network motifs: simple building blocks of complex networks. Science 298(5594):824–827

Minoiu C, Reyes JA (2011) Network analysis of global banking: 1978–2009. International Monetary Fund

Mu G-H, Zhou W-X, Chen W, Kertész J (2010) Order flow dynamics around extreme price changes on an emerging stock market. N J Phys 12(7):075037

Nardini C, Kozma B, Barrat A (2008) Whos talking first? Consensus or lack thereof in coevolving opinion formation models. Phys Rev Lett 100(15):158701

Newman MEJ (2009) Networks: an introduction. Oxford University Press, Oxford

Newman MEJ, Barabasi A-L, Watts DJ (2011) The structure and dynamics of networks. Princeton University Press, Princeton

Nier E, Yang J, Yorulmazer T, Alentorn A (2007) Network models and financial stability. J Econ Dyn Control 31(6):2033–2060

Onnela JP, Chakraborti A, Kaski K, Kertesz J (2003a) Dynamic asset trees and black monday. Phys A Stat Mech Appl 324(1):247–252

Onnela JP, Chakraborti A, Kaski K, Kertesz J, Kanto A (2003b) Dynamics of market correlations: taxonomy and portfolio analysis. Phys Rev E 68(5):056110

Onnela J-P, Saramäki J, Hyvönen J, Szabó G, Lazer D, Kaski K, Kertész J, Barabási A-L (2007) Structure and tie strengths in mobile communication networks. Proc Natl Acad Sci 104(18):7332–7336

Parshani R, Buldyrev SV, Havlin S (2010) Interdependent networks: reducing the coupling strength leads to a change from a first to second order percolation transition. Phys Rev Lett 105(4):048701

Parshani R, Dickison M, Cohen R, Stanley HE, Havlin S (2010) Dynamic networks and directed percolation. Europhys Lett 90(3):38004

Pastor-Satorras R, Vespignani A (2001) Epidemic spreading in scale-free networks. Phys Rev Lett 86(14):3200–3203

Pastor-Satorras R, Vespignani A (2007) Evolution and structure of the internet: a statistical physics approach. Cambridge University Press, Cambridge

Radicchi F, Fortunato S, Castellano C (2008) Universality of citation distributions: toward an objective measure of scientific impact. Proc Natl Acad Sci 105(45):17268–17272

Reis SD, Hu Y, Babino A, Andrade JS Jr, Canals S, Sigman M, Makse HA (2014) Avoiding catastrophic failure in correlated networks of networks. Nat Phys 10:762–767

Sandaval L Jr, Franca IDP (2012) Correlation of financial markets in times of crisis. Stat Mech Appl 391(1):187–208

Sandoval L (2014) Structure of a global network of financial companies based on transfer entropy. Entropy 16(8):4443–4482

Sendiña-Nadal I, Ofran Y, Almendral JA, Buldú JM, Leyva I, Li D, Havlin S, Boccaletti S (2011) Unveiling protein functions through the dynamics of the interaction network. PLoS One 6(3):17679

Shai S, Kenett DY, Kenett YN, Faust M, Dobson S, Havlin S (2014) Resilience of modular complex networks (preprint). arXiv:1404.4748

Shao J, Buldyrev SV, Braunstein LA, Havlin S, Stanley HE (2009) Structure of shells in complex networks. Phys Rev E 80(3):036105

Solomon S, Weisbuch G, de Arcangelis L, Jan N, Stauffer D (2000) Social percolation models. Phys A Stat Mech Appl 277(1):239–247

Song C, Havlin S, Makse HA (2005) Self-similarity of complex networks. Nature 433(7024):392–395

Soramäki K, Bech ML, Arnold J, Glass RJ, Beyeler WE (2007) The topology of interbank payment flows. Phys A Stat Mech Appl 379(1):317–333

Tesfatsion L (2002) Agent-based computational economics: growing economies from the bottom up. Artif Life 8(1):55–82

Tesfatsion L (2003) Agent-based computational economics: modeling economies as complex adaptive systems. Inf Sci 149(4):262–268

Tumminello M, Coronnello C, Lillo F, Micciche S (2007a) Spanning trees and bootstrap reliability estimation in correlation based networks. Int J Bifurc Chaos 17:2319–2329

Tumminello M, Di Matteo T, Aste T, Mantegna R (2007b) Correlation based networks of equity returns sampled at different time horizons. Eur Phys J B Condens Matter Complex Syst 55(2):209–217

Tumminello M, Lillo F, Mantegna RN (2010) Correlation, hierarchies, and networks in financial markets. J Econ Behav Organ 75(1):40–58

Upper C, Worms A (2004) Estimating bilateral exposures in the German interbank market: is there a danger of contagion? Eur Econ Rev 48(4):827–849

Wells S (2002) UK interbank exposures: systemic risk implications. Financ Stab Rev 13:175–182

Yamasaki K, Gozolchiani A, Havlin S (2008) Climate networks around the globe are significantly affected by El Nino. Phys Rev Lett 100(22):228501

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